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Children's Pedagogical Competence and Child-to-Child Knowledge Transmission: Forgotten Factors in Theories of Cultural Evolution

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Abstract

Theories of cultural evolution tend to agree that teaching is one of the most powerful social learning mechanisms whereby knowledge gets passed on from one generation to the next. Researchers have mainly focused on the communicative signals adults produce when teaching. Natural pedagogy theory, for example, discusses how adults' use of ostensive communication leads children to adopt a learning stance and interpret the information they receive as generalizable (Gergely & Csibra, 2013). A consequence of this is that children are almost exclusively cast in the role of beneficiaries of others' pedagogy. We argue that young children are not just receptive to teaching – they have pedagogical skills that have not been recognized by theories of cultural evolution. Children's pedagogical competence manifests in their selective and learner-sensitive teaching of others. We urge theories of cultural evolution to recognize that children receive knowledge not just from adults but also from other children.

Keywords

cultural evolution – social learning – pedagogy – child development

1 Children's Pedagogical Competence and Child-to-Child Knowledge Transmission: Forgotten Factors in Theories of Cultural Evolution

Teaching is a powerful mode of learning by which culture is passed on between generations and accumulates over historical time (Caldwell et al., 2018; Fogarty et al., 2011; Tennie et al., 2009; Tomasello et al., 1993). More than just preserving existing cultural forms, teaching encourages learners to seek knowledge beyond what they have been taught, thereby inspiring cultural change and innovation (Small, 2014). Teaching is thus a major cultural evolutionary force, as it aspires to give each new generation of learners knowledge for them to use and expand. Although it has been argued that teaching is absent in some cultures (Lancy, 2016), most scholars agree that teaching is a learning-oriented form of communication found in all human societies (e.g., Gergely & Csibra, 2011).

In this article, we explore the significance not only of teaching, but of learners' *understanding of the process and goal of teaching* – their pedagogical cognition and competence – for cultural evolutionary theory. Our point will be that although teaching has been recognized as a key mechanism of cultural evolution, not enough attention has been dedicated to children's pedagogical cognition and how it might contribute to cultural evolution. Empirical data indicate that from a young age on, children not only benefit immensely from being taught but also have a remarkable grasp of and an early capacity for teaching. We will suggest that children play a much more active part in cultural transmission than has been recognized, not just as recipients of others' knowledge but also as sharers and spreaders of knowledge in their own right. It must therefore be assumed that knowledge, in addition to being exchanged among adults and handed down from older to younger generations, is also transmitted intragenerationally between children, and possibly upward from children to older generations (see Figure 1).

The article has three parts. In the first part, we survey studies supporting humans' early sensitivity to teaching. Here, we also review evidence suggesting that pedagogy tends to be more powerful than incidental forms of learning and learning by testimonial reports, in which a speaker shares particular "bits" of information with a learner rather than pedagogically transmitting general knowledge. In the second part, we introduce studies showing that by preschool age, children have an astonishing understanding of and capacity for teaching. In the third and final part, we draw inferences about the relevance of these findings for cultural evolution and raise what we believe are important questions for future research.

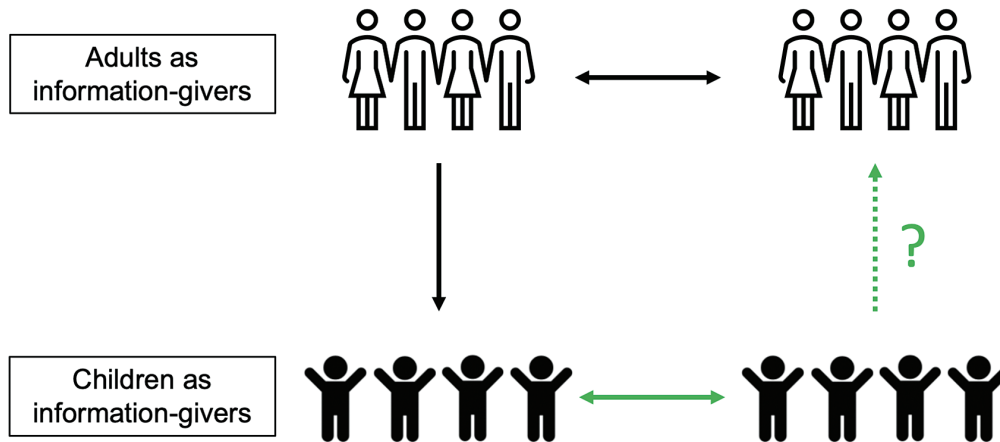


FIGURE 1 Intergenerational and intragenerational knowledge transmission of adults and children

Note. Existing models of cultural evolution exclusively attend to intergenerational transmission from adults to children and *intragenerational* transmission between adults (black arrows). We argue that these models neglect *intragenerational* knowledge transmission between children (solid green arrow), which we mainly discuss in this article. A question for future exploration is child-to-adult knowledge transmission (dotted green arrow) and its role in cultural evolution (e.g. in the context of immigration, technological advances, etc.).

Before discussing children's receptiveness to teaching, one might want to try to define what teaching is. A definition will help distinguish teaching from weaker forms of social learning that play no or a less important role in cultural evolution, and it will give researchers of human and animal behavior criteria to decide whether an interaction qualifies as teaching.

Various definitions of teaching have been given, from mentalistic to functional ones (see Kline, 2015). Mentalistic definitions maintain that teachers "read" and influence their learner's mind (e.g., address their lack of knowledge), and learners, in turn, recognize and engage with the teacher's intentions regarding their mental states (Tomasello et al., 1993). Because of the poor detectability of mind-reading and the risk of overlooking potential teaching instances in non-human animals, others have tried to define teaching in purely functional terms. For Caro and Hauser (1992, p. 153), for example, teaching occurs when a creature "modifies its behavior only in the presence of a naive observer" with the effect that the observer "acquires knowledge or learns a skill earlier in life or more rapidly or efficiently than she might otherwise do." Although we are sympathetic to the idea of focusing on what goes on between agents rather than in their individual minds, we believe that functional

definitions like this one fail because they are overinclusive or, where they are not, they sneak intentionality back (e.g., by speaking of “guided instruction”, which presupposes a teacher’s sense of where the learner cognitively stands and in which direction her cognition should be further developed). Imagine A holding a fragile container when B appears. B’s presence makes A nervous, so that A drops the container, the content of which is thereby revealed to B. Per Caro and Hauser’s (1992) definition, A and B are in a teaching relationship, when, clearly, they are not.

We think that reference to teleological action and intention is unavoidable if teaching is to be distinguished from lucky learning “accidents” like the one just sketched. Our own, “mildly mentalistic”, definition of teaching, is inspired by shared intentionality theory and stresses the mutual engagement of learner and teacher in a joint attempt to further the learner’s knowledge (see also Moll, 2020; Moll & Kern, 2020). In this definition, teaching occurs when agents cooperate and communicate with the goal to have one or more of the involved individuals acquire general knowledge from the other(s). With this as a rough guide of what teaching is, we now turn to children’s sensitivity to others’ pedagogy.

2 Children’s Responsiveness to Teaching

Natural pedagogy theory has argued and given evidence that even infants are receptive to teaching (Egyed et al., 2013; Futó et al., 2010; Topál et al., 2008; Yoon et al., 2008). For example, when an adult rejects an object with pedagogical signals – by making eye contact with the infant and then ostensively displaying disgust toward the object – the infant tends to attribute negative qualities to the object. However, when the adult does not address the infant pedagogically, the infant simply assumes that the adult is expressing her subjective attitude toward the object (Egyed et al., 2013).

By preschool age, pedagogy has profoundly shaped children’s cognition. When pedagogically introduced to objects, 3- and 4-year-olds form kind-general expectations and let these expectations guide their explorations of new object exemplars (Bonawitz et al., 2011; Butler & Markman, 2012; Shneidman et al., 2016). Pedagogy has also been shown to help preschoolers solve problems that are otherwise beyond their capacity. For example, when 4-year-olds are pedagogically informed that water can be used to solve mechanical problems (“Water can be used as a tool!”), they are more likely to master tasks than they otherwise would (Moll, 2018). Crucially, speaking *non-pedagogically* about an event in which water is used to solve a mechanical problem does not have the

same effect, indicating that teaching is more powerful than incidental forms of learning. But not only pedagogically framed assertions do the trick: pedagogical questions, i.e., questions geared to advance the listener's learning, have likewise been shown to improve children's causal understanding (Daubert et al., 2020; Yu et al., 2019). In sum, infants and young children uniquely benefit from pedagogy compared to other forms of learning (Gweon & Schulz, 2019).

3 The Origins of Pedagogical Cognition

Empirical evidence suggests that teaching is a unique type of cultural transmission because it allows for complex skills, such as tool use, to be transmitted with high fidelity (Morgan et al., 2015). Over the past two decades, researchers have studied the development of children's understanding of teaching (see Ronfard & Harris, 2018, for a review) and have found that their pedagogical knowledge rapidly progresses between the ages of 3 to 7. During this time, children come to understand teaching as a process resulting in an increase of the learner's knowledge (Sobel & Letourneau, 2016), while also acknowledging that the tutor's intention is important for an instance of learning to be the outcome of teaching (Ziv & Frye, 2004; Ziv et al., 2008). When teaching, children adjust the form and content of their speech (Gelman et al., 2013; Pueschel et al., submitted, a), take the source of their own knowledge into consideration (Vredenburg et al., 2015), and factor in the learner's knowledge, goals, and competence (Baer & Friedman, 2018; Bridgers et al., 2020; Danovitch et al., 2020; Gweon & Schulz, 2019). In the following sections, we will elaborate on each of these capacities in turn.

3.1 *Children's Sensitivity to the Nature of the Information*

Ziv and colleagues (2008) explored when children come to learn that teaching begins with an epistemic gap between teacher and learner. The authors found that even 3-year-olds understand that it is a condition of teaching that one party has knowledge the other is lacking. By age 5, children understand that the teacher must be aware that a knowledge gap exists between her and the learner for her to approach the other with pedagogical intent.

Sobel and Letourneau (2016) asked children between 4 and 7 years old to reflect on what teaching is and to give examples of teaching. By around age 6, children defined teaching as a process geared to expand the learner's knowledge. Taken together, these findings suggest that by the time children reach school age, they explicitly understand teaching to be a communicative process

whereby one party comes to learn what another party already knows. But as we shall see, prior to having such a definition of teaching, children possess a wealth of know-how that must be recognized as constituting skillful teaching.

What distinguishes teaching from other, merely testimonial acts of communication, is the generality of what is transmitted. Gelman et al. (2013) pointed out that pedagogy is replete with generic language, i.e., statements not about particulars but about kinds, species, or classes of objects. Genericity is central to teaching because unlike testimony, which gives information of particular instances or events, teaching, if it succeeds, provides a general comprehension of the world. As Rödl (2020, p. 300), expanding on Locke (1975), writes, “Testimony gives leaves and dust, teaching gives gold. For teaching gives principles through which she who is taught understands why things are as they are.”

To explore children’s understanding of the nexus of teaching and generality, Gelman et al. (2013) asked 5- and 6-year-olds to either pretend to teach someone or to have a conversation with a friend. Results revealed that children used more generic language when they engaged in teaching whereas they made more references to particular events when holding a non-pedagogical conversation. Pueschel et al. (submitted, a) took these results further by including younger children and separately measuring children’s use of generic language and their selection of general content when teaching. They observed that by age 4, children not only produce more generic speech but also, independent of linguistic form, select more general rather than episodic content when asked to teach someone than when asked to narrate an event.

It is helpful at this point to remind oneself that “teach” and “learn” are what Ryle (1949) called “success verbs”: they denote activities that culminate in a desired outcome. What teaching aspires to achieve is knowledge and therefore access to the truth. A person who “teaches” falsehoods does not, in fact, teach. One might ask when children come to understand that teaching aspires to spread the truth. To investigate this, Pueschel et al. (submitted, b) gave 3- and 4-year-old children pieces of information that were marked as either true or false. Children were then invited to share information with others. While 3-year-olds struggled with the overall task demands, most 4-year-olds stuck to the truth and selectively conveyed information that had been verified.

Taken together, we find that by around 4 years old, children are aware that teaching involves a special kind of communicative exchange the goal of which is to help one of the participants, the learner, gain access to valuable knowledge she does not yet possess.

3.2 *Children’s Sensitivity to the Learner*

A critical development in children’s teaching is their ability to tailor the content of their instruction to the learner’s need. Young children take into account

the mistakes, motivation, and maturity of the learner when teaching (Gweon & Schulz., 2019; Ronfard & Corriveau, 2016; Qiu et al., submitted). Ronfard and Corriveau (2016) presented 3- to 5-year-olds with several puppets playing a game. Some puppets played the game perfectly, while others violated either one rule or two rules of the game. Five-year-olds provided more targeted instruction that directly addressed the specific mistake the puppet made, as opposed to being under-informative (addressing only one mistake if two mistakes were made) or over-informative (teaching the puppet both rules when the puppet only violated one). By contrast, 3- and 4-year-olds did not address the specific mistake made by the learner.

Effective pedagogical communication typically requires consideration of the learner's knowledge, maturity, and expertise. Whereas we might let a toddler know, "We drink from cups", we might inform an adult, "Some thermos bottles can keep drinks cool for more than 24 hrs." Baer and Friedman (2018) found that even preschool children factor in their audience's prior knowledge when teaching them. In their study, 4- and 5-year-olds shared more elaborate information with an expert than they did with a novice, whom they gave more fundamental information. A study by Qiu et al. (submitted) found that children can infer the appropriate level of complexity of information solely on the basis of the learner's biological maturity. When asked to teach a baby or an adult, 7-, but not 5-year-olds, modified the complexity and taught more complex information to the adult and more basic information to the baby.

Young children not only adjust the content of their instruction depending on the learner's knowledge and learning capacity; they also vary their teaching strategies based on the learner's engagement and provide explanations that are tailored to the learner's mental state. In a series of naturalistic observations of sibling dyads, Howe and colleagues (2005, 2013) found that older siblings adjusted their teaching strategies as a function of the younger child's level of engagement. When the younger sibling was actively involved in the exchange, the older sibling used more direct instruction, planning, clarification, and positive feedback than when the younger sibling ignored the instructions or merely complied. Another study found that by age 4, children provide explanations and offer contradictory evidence to correct a learner's false assumptions, suggesting that children consider the learner's mental states when teaching (Bass et al., 2019).

3.3 *Children's Developing Teaching Strategies*

Preschoolers have proven themselves to be effective teachers: they consider the nature of the information and the needs of the learner when informing others. Additionally, the teaching strategies in their tool-box grow rapidly between the ages of 4 and 7 (Howe et al., 2012; Maynard, 2002; Pratt et al., 1977;

Ziv et al., 2016). Children become increasingly explicit in their teaching; they flexibly vary their teaching strategies and offer more explanations. Ziv et al. (2016) examined preschoolers' teaching strategies and found that whereas 3-year-olds often did not respond to a learner's questions or errors, 5-year-olds adjusted their instruction to the learner's mistakes. Additionally, children went from using shorter directives like, "Do this" and "Stand here", to using more verbal explanations. Strauss and colleagues (2002) observed a developmental progression of teaching strategies, with the production of informative gestures as a precursor of teaching present in infancy, followed first by simple demonstrations and then, in late preschool and elementary school, the use of increasingly elaborate and complex verbal instructions and explanations. This sequence roughly mimics the phylogenetic sequence that O'Madagain and Tomasello (2021) propose emerged in hominin evolution, with *homo heidelbergensis* engaging in "demonstrative pedagogy" to introduce novices to the construction of (Acheulean) stone tools around 400,000 years ago, followed by propositional, and more normatively charged, forms of pedagogy with the emergence of modern humans around 200,000 years ago.

4 How to Account for Child Teachers in Cultural Evolutionary Theory

Theories of cultural evolution offer explanations for cultural inheritance mediated not by genetic transmission but by learning. So far, these theories have focused on children as mere beneficiaries in downward transmissions of knowledge, customs, and practice. What our survey of young children's pedagogical cognition and capacity suggests is a more serious consideration of children as benefactors in the exchange of knowledge.

As the research reviewed in Section 2 shows, children have a lot more agency in social learning interactions than previously assumed. Far from being "information sinks" or "sponges" that soak up information, they play an active part in the cooperative endeavor of teaching. They master both complementary roles, that of the learner and the teacher, and are responsive to their interaction partner's specific role and perspective. In their sibling interaction studies, Howe et al. (2005, 2013) noted a bidirectional influence of learner involvement and active teaching, such that child teachers elaborated their instructions when the learner was actively involved, and learners, in turn, increased their involvement in response to more thoughtful instruction. Overall, these findings confirm the thesis that children understand teaching to be a second-personal and cooperative undertaking, involving bidirectional exchange between two parties striving to increase the learner's comprehension (Moll, 2020; Moll & Kern, 2020).

Our shared intentionality thesis maintains that human children are unique social learners because they understand the cooperative structure underlying social acts such as giving-taking or telling-listening. These actions are special in that the success of the initial part of the action, e.g., the giving, hinges on the recipient's uptake – the acceptance of what is being offered. Initially, children's engagement is limited to the receptive part: they take the object before offering it, they understand others' speech before they can reply. But, unlike other animals, infants soon learn to reverse roles (Carpenter et al., 2005) and offer an object, reply to a question, or, within the somewhat more complex teaching relation, share what they know with others. Children cognize the joint action not exclusively from "within" one of the roles but represent the action from a bird's eye view, with at least a rudimentary understanding of the complementary role (Tomasello, 2019). In this account, one major reason why teaching is absent in other animal species is that they lack the cooperative organization that necessarily underlies social acts such as teaching.

Cultural evolutionary theories need to acknowledge children's bidirectional capacities in the context of teaching and learning. *Intragenerational* (horizontal) transmission is not limited to exchanges between mature or juvenile species members, as these theories have suggested, but is also present in children. One might be skeptical whether the above-reviewed studies alone provide evidence of robust child-to-child teaching in real life, since many of these studies involved a mere simulation of a learner in the form of a puppet, an adult experimenter, or even just an imagined audience. In response to this skepticism, we would point out that in several studies, children did in fact teach children (e.g., Ashley & Tomasello, 1998; Howe & Recchia, 2005, 2009; Maynard, 2002; Ziv et al., 2016). The same is true of "diffusion chain" studies, in which children, who are used as stand-ins for entire generations, have been shown to pass on knowledge with considerable reliability across multiple "generations" (Flynn, 2022). Dean and colleagues (2012) compared horizontal cultural transmission in young human children, capuchin monkeys, and chimpanzees using a puzzle box with different stages of increasing difficulty. Not only did human children by far outperform the other animals in reaching higher levels of difficulty, but children who taught also outperformed those who did not. Although we agree with Miton and Charbonneau's (2018; see also Charbonneau and Strachan, 2022) arguments that diffusion chain studies do not succeed in simulating cross-generational transmission in historical time, they certainly do demonstrate children's capacity for mutual knowledge exchange outside of adult intervention.

In further support of intragenerational knowledge transmission among children, it has been shown that children share and pass on traditions in the form of rhymes, riddles, and games (Opie & Opie, 2000). Some of these traditions

have lasted for centuries (Morin, 2016). Children thus possess a subculture that is more or less independent from the culture they share with other generations. The childhood subculture gets constantly reproduced as new children enter the scene. That children come up with cultural practices of their own is perhaps unsurprising considering how much time many of them spend outside of adult supervision. Mayan children in Guatemala and Aka children in Central Africa, for example, spend more than half of the time in each other's company with no adult present (Ellis, Rogoff, & Cromer, 1981; Hewlett et al., 2011).

Though we hope to have shown that children are budding pedagogues, we do not question that adult-to-child transmission is the leading path toward cumulative culture. The first learning relationships children find themselves in are with adults, not other children, and so the earliest and most fundamental knowledge stems from adults. That adults remain better and, in many cases, preferred, teachers for children was shown by Ellis and Rogoff (1982). In their study, 9-year-olds and adults were asked to teach 7-year-olds about school and household items from various categories. Those taught by adults learned to classify objects better than those who were taught by other children. Children taught by adults were also more reciprocally engaged in the pedagogical exchange. Adults, of course, have advanced pedagogical skills compared to children, who have just begun to acquire the art of teaching.

Nonetheless, there are domains and circumstances in which children favor child teachers. As the above-cited work on childhood traditions has shown, children seek each other's knowledge in the context of playful pastime (Morin, 2016). This is supported by experiments showing that children address either peers or adults, depending on the knowledge domain (Fitneva, 2010; Taylor et al., 1994; VanderBorghet & Jaswal, 2009). Children prefer child informants in areas revolving around play, such as when they want to learn about toys or how to jump rope. They prefer to learn from adults, however, when interested in tools or in how to cross a street with traffic lights. Children thus find other children better informants when it comes to fun and play, but deem adults more knowledgeable when wanting to find out how the world works and how to properly move in it.

To conclude, in this article we shed light on a key mechanism responsible for cultural evolution: teaching. We showed that far from being passive recipients of others' knowledge, children play an active role in teaching that was not sufficiently recognized. Not only does successful learning from pedagogy require the learner's active participation in a shared, cooperative activity with a tutor (Moll, 2020; Moll & Kern, 2020), but children also skillfully adopt the role of teachers at a young age. Future research should investigate the effects of active teaching in consolidating one's own knowledge and, potentially,

in increasing the benefits of receiving instruction from others. Does being a good teacher make one a better learner, and vice versa? Do children perceive teaching differently in cultures in which they spend a majority of their time with adults (more opportunities for downward transmission) as opposed to with other children (more opportunities for horizontal transmission)? These and other open questions, such as the conditions under which children teach adults (e.g., immigration, recent technological advances) are objects of future investigation.

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